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Seed Source Influences Juniper Seedling Survival Under Severe Drought Stress

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Thirty-nine sources of eastern redcedar (*Juniperus virginiana* L.) and 15 sources of Rocky Mountain juniper (*Juniperus scopulorum* Sarg.), representing collections from throughout the Great Plains, were planted in 1980 as 2 + 0 stock in south-central Oklahoma. Extremely droughty conditions during 1980 resulted in 77% first-year mortality. Percent survival of seedlings, by source, showed a low and negative, but statistically significant ($p = 0.05$) correlation ($r = -0.21$) with mean nursery height. Survival of Rocky Mountain juniper was greater (32%) than survival of eastern redcedar (20%). Analysis of covariance (with height as the covariate) of percent survival by species showed source differences in survival only for eastern redcedar. Selection of optimum species and seed sources should improve survival of junipers in windbreak plantings on severe sites in the Great Plains.

Keywords: *Juniperus scopulorum*, *J. virginiana*, drought, survivability, seed source

Management Implications

The western two-thirds of Oklahoma is within the Great Plains region. This portion of the plains is subject to strong and persistent winds, and cyclic periods of drought. These conditions can pose serious threats to farmers and ranchers by eroding soils, by damaging or destroying crops, and by reducing livestock gains. Winds in excess of 25 m.p.h. can cause severe soil erosion (Roberts and Craighead 1961).

Effective tree windbreaks can reduce wind speed by half; but, to establish such windbreaks, the tree species used must demonstrate high survivability under relatively adverse conditions. Junipers can provide this needed protection. However, many plantings of juniper in the southern plains have failed due, in part, to use of improper species or to nonadapted seed sources within a species. Identification of a juniper species and seed sources within that species, which demonstrate high survivability under stress conditions, would greatly increase the probability of establishing effective windbreaks in the southern Great Plains.

Introduction

Junipers have been planted in windbreaks in Oklahoma for almost 50 years, and eastern redcedar (*Juniperus virginiana* L.) is a major component in many of them. Performances of Rocky Mountain juniper (*Juniperus scopulorum* Sarg.) on very dry, infertile sites, and of eastern redcedar on slightly better sites, indicate that both species are capable of surviving under difficult con-

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ditions (George 1953, USDA 1965). The inherent ability of the junipers to survive on extreme sites has resulted in their extensive use; they are often the only surviving coniferous species.

Survival of seed sources of Rocky Mountain juniper and eastern redcedar seedlings under extremely adverse conditions was examined in this study. The original objective was to determine the suitability of these species as components of windbreaks for central and western Oklahoma. The late-season extreme drought, following planting in the spring of 1980, disallowed meeting the original objective, but did provide information on first-year survival under severe stress.

Materials and Methods

The seedlings were obtained through a Great Plains Agricultural Council project in which seed was collected throughout the Great Plains and sown at the USDA Forest Service Bessey Nursery in Halsey, Nebr.

The Oklahoma planting of this study contained 164 open-pollinated families of eastern redcedar and Rocky Mountain juniper from across the Great Plains. The seed collection represented 54 seed zones (sources),[4] with 1 to 5 families per zone in 10 states (fig. 1) (Cunningham 1975). The plantation was established in Stephens county, 4.5 miles east of Marlow, Oklahoma, on an old field site. Seedlings were spaced 7 feet apart within rows 13 feet apart. Five replicates were planted. Because of the large size of the replicates each was divided into 14 blocks of families (i.e., incomplete blocks) to account for environmental variance within blocks. Families were represented by 4-tree linear plots. Grass was controlled with a herbicide before the seedlings were planted.

Seedlings were planted as 2 + 0 bare-root stock in April 1980. There was a severe drought during the summer of 1980, with no rain in July and August and temperatures higher than normal (table 1). Rainfall for the year was 13.8 inches below average. The drought resulted in 77% seedling mortality. Survival data were collected in April 1981, and percent survival through the first year was calculated.

Statistical analysis included a simple correlation of mean nursery height with survival on a seed zone and family basis for the plantation and by species. Mean nursery heights were obtained from Comer (1981) for 99 of the 164 families (42 seed zones) in the test. Only families for which both mean nursery height and first-year field survival data were available were used in the analysis. A covariance analysis was computed to test for survival differences adjusted for nursery height among seed zones by both species. All tests of significance were at the $p = 0.05$ probability level.

Results and Discussion

Percent survival and mean nursery heights of seedlings by seed zones for each species are presented in Table 2. The seed zones are listed from north to south. Of the 3,280 seedlings planted, 23% survived the first year. The average survival for Rocky Mountain juniper was 32%, with a range of 0 to 50%. Eastern redcedar showed an average survival over seed zones of 20%, with a range of 0% to 48%. The ranges in survival of the two species appear similar; however, examination of survival by seed zone revealed that Rocky Mountain juniper was the better survivor, as the means suggest. Seedlings in 75% of the Rocky Mountain juniper seed zones showed 30% or higher survival. In contrast, eastern redcedar seedlings in 79% of the seed zones represented had 30% or lower seedling survival.

Figure 1.—Seed collection zones for Rocky Mountain juniper and eastern redcedar.

The correlation of percent survival (entire planting) with mean nursery height was negative and statistically significant ($r = -0.53$). Correlations by species (family basis) showed that percent survival of eastern redcedar was negatively and significantly correlated with mean nursery height ($r = -0.56$). Rocky Mountain juniper also showed a negative correlation ($r = -0.22$) between survival and height, but this was not statistically significant. This analysis suggests that nursery heights affect the survivability of eastern redcedar seedlings under extreme drought conditions.

The analysis of covariance (using nursery height as a covariate) for percent survival showed significant seed zone differences. This analysis revealed a higher survival for northern sources. Most of the northern seed zones contain Rocky Mountain juniper. The seedlings derived

[4]All families within a seed collection zone were treated as a seed source; thus, in this paper the terms zone and source are used interchangeably.

Table 1.—1980 Climatological data at Marlow, Okla. 4.5 miles east of the plantation.

Month	Average temp.	Departure	Rainfall	Departure	Days ≥ 90°
	---------F°---------		---------in.---------		no.
Jan.	40.4	0.0	1.28	+0.02	0
Feb.	40.7	- 4.4	0.96	- 0.51	0
March	49.2	- 2.8	1.59	- 0.29	0
April	61.8	- 2.0	0.60	- 2.37	0
May	70.1	- 0.7	5.12	- 0.96	5
June	83.0	+4.3	1.34	- 2.66	23
July	89.5	+6.2	0.00	- 2.36	31
Aug.	86.9	+3.7	Trace	- 2.40	30
Sept.	78.2	+2.6	3.73	0.16	21
Oct.	62.9	- 2.2	0.82	- 2.39	0
Nov.	51.3	- 1.1	1.50	- 0.29	0
Dec.	45.3	+1.9	1.72	0.27	0
Year			18.66	- 13.78	

Table 2.—Percent survival and mean nursery height of Rocky Mountain juniper and eastern redcedar.[1]

Seed zone no.	Location	Survival	Mean height[2]
		percent	*mm*
Rocky Mountain juniper			
531	MT	40.0	384
461	MT	40.0	283
581	MT	37.5	316
582	MT	37.5	290
585	MT	40.0	257
584	SD	37.5	291
321	WY	30.0	304
*331	WY	15.0	214
331	WY	50.0	284
671	WY	10.0	270
641	NE	40.0	335
830	NM	5.0	470
Mean		31.9	308.2
Eastern redcedar			
534	SD	43.3	343
631	SD	0.0	344
661	NE	31.0	352
651	NE	28.8	336
652	NE	48.0	323
1023	NE	35.0	341
751	NE	25.0	308
1071	IA	10.0	310
1072	IA	27.0	399
731	NE	28.0	350
1061	NE	37.5	367
721	KS	0.0	360
761	KS	20.0	376
732	KS	24.0	385
741	KS	13.3	409
752	KS	25.0	451
1121	KS	19.0	382
762	KS	22.5	363
801	KS	10.0	416
781	KS	25.0	411
1122	OK	20.0	385
802	OK	15.0	490
841	OK	4.0	407
1191	OK	6.7	403
851	TX	5.0	479
861	TX	6.0	427
871	TX	7.5	467
1332	TX	0.0	425
862	TX	3.3	366
Mean		19.7	385.3

[1]Seed zones are listed from north to south for each species.
[2]Nursery heights from Comer (1981).

from trees in these northern seed zones were shorter; a factor that may have contributed to higher percent survival for Rocky Mountain juniper. Shorter seedlings have less leaf surface from which to transpire moisture in the warmer, dryer, Oklahoma environment. Also, Rocky Mountain juniper leaves contain more insulating cutin (wax) than eastern redcedar leaves. Thus, they would be expected to transpire and dessicate less than eastern redcedar. Shortness may be a physical characteristic—an indicator trait—related to drought resistance achieved through adaptive differentiation.

Analysis of covariance by species showed significant differences among eastern redcedar seed zones ($p = 0.05$ level). Clinal variation was suggested by differences among seed zones for eastern redcedar. Results indicate that seed origin has an effect on eastern redcedar survivability and should be considered when selection is applied. The analysis of covariance showed no significant differences among Rocky Mountain juniper seed zones. Other studies of Rocky Mountain juniper and eastern redcedar seedling performances indicate that survival is strongly influenced by soil type, age of planting stock, soil texture, and weather conditions during and for several years after planting (Afanasiev, 1948, 1949a, 1949b).

Conclusions

Sufficient geographic variation in first-year survival exists to indicate that genetic improvement in survivability on difficult sites is possible through selection. Analyses indicate that greatest initial gains can be obtained through source selection. Results show that Rocky Mountain juniper seedlings have better first-year survival than eastern redcedar seedlings when planted in south-central Oklahoma. Rocky Mountain juniper had lower mean nursery heights, indicating slower initial growth. Correlations between survival and mean nursery heights suggest that variation in heights of 2 + 0 planting stock affect first-year field survival in eastern redcedar only. The long-term importance of seedling height when outplanted in relation to survival has yet to be determined, but during drought in the establishment year, shorter trees may have higher survival rates. Reliable in-

formation on the effect of seed origin and initial nursery height on survivability can be obtained only by field testing selected species and varieties.

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